The Astronomical Journal, 142:46 (4pp), 2011 August doi:10.1088/0004-6256/142/2/46

SPECKLE INTERFEROMETRY AT THE U.S. NAVAL OBSERVATORY. XVII.

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Received 2011 May 13; accepted 2011 June 8; published 2011 June 30

ABSTRACT

The results of 3362 intensified CCD observations of double stars, made with the 26 inch refractor of the U.S. Naval Observatory, are presented. Each observation of a system represents a combination of over 2000 short-exposure images. These observations are averaged into 1970 mean relative positions and range in separation from 0.″78 to 72.″17, with a mean separation of 14.″76. This is the 17th in this series of papers and covers the period 2010 January 6 through December 20. Also presented are 10 pairs that are resolved for the first time.

Key words: binaries: general – binaries: visual

Online-only material: machine-readable and VO tables

1. INTRODUCTION

This is the 17th in a series of papers from the U.S. Naval Observatory's speckle interferometry program, presenting results of observations obtained at the USNO 26 inch telescope in Washington, DC. Over 24,000 mean positions have now resulted from this program since its inception by Charles Worley, Geoff Douglass, and colleagues in the early 1990s (see Douglass et al. 1997).

From 2010 January 6 through December 20, the 26 inch telescope was used on 77 of 257 (30%) scheduled nights. Most nights were lost due to weather conditions, but time was also lost due to equipment upgrades, mechanical issues, and to personnel observing on other telescopes. Since our primary speckle camera was in use at other facilities during this period, all of these observations were obtained with the secondary camera, described by Mason et al. (2007). As described in Mason et al. (2011), the ICCD used on our secondary or "backup" camera failed at the end of 2008 and our primary camera was used in its place. In late 2009 a replacement ICCD was procured; following a testing/verification phase this new ICCD was installed on the primary camera head and the older ICCD was installed on the secondary camera head. To within detectable errors the sensitivity, pixel ratio, and capabilities of the new ICCD are identical with the older unit. The new ICCD and primary camera head were subsequently shipped to Cerro Tololo for observations on the CTIO 4 m.

Most of the systems observed with this camera have separations well beyond the regime in which there is any expectation of isoplanicity. These images are almost direct CCD imaging observations, but utilize the short exposure time and a variant of the autocorrelation reduction method to generate a two-dimensional autocorrelogram. Each measurement is the result of many hundreds of correlations per frame, and up to several thousand frames per observation.

While individual nightly totals varied substantially (from 8 to 101 objects per night, mean = 43.7, median = 45) the results yielded 3362 observations and 3261 resolutions (i.e., usable double star measurements). After removing marginal observations, calibration data, and tests, a total of 3093 measurements remained, which were grouped into 1963 mean positions. Included in these are 45 confirmations of double stars with only one previous observation. While 14 of these are relatively recent discoveries of the *Hipparcos* or *Tycho* missions (ESA 1997), some of these pairs had remained unconfirmed for over 100 years.

Observing list construction and calibration procedures remain the same as those described for the secondary camera in Mason et al. (2007). The plate scale of this camera is not appropriate for the slit-mask calibration used in Mason et al. (2007) for the primary camera, so well-observed double stars are used to evaluate system accuracy and precision. Evaluation of the ensemble of tabulated $O - C$ values in Table 3 allows the error to be grossly characterized as $\pm 1.^{\circ}0$ and $\pm 1\%\rho$.

2. RESULTS

2.1. New Pairs

Table 1 presents coordinates and magnitude information from CDS[1] for 10 pairs which are measured here for the first time. All were observed as closer components to known systems or in the same field of view. Column 1 gives the coordinates of the primary of the pair; Column 2 is the discoverer designation (where WSI = Washington Stellar Interferometer) number. Columns 3 and 4 give the estimated visual magnitudes of the primary and secondary of the pair described here, and Column 5 notes the circumstance of the discovery. The mean relative astrometry (T, θ, and ρ) of these systems is given in Table 2.

2.2. Measures of Known Pairs

Table 2 presents the mean relative positions of the members of 1588 systems having no published orbital or linear elements. The first two columns identify the system by providing its epoch-2000 coordinates and discovery designation. Columns 3 through 5 give the epoch of observation (expressed as a fractional Besselian year), the position angle (in degrees), and the separation (in seconds of arc). Note that the position angle has not been corrected for precession or nutation, and is thus based on the true equinox for the epoch of observation. For

[1] Magnitude information is from the Aladin sky atlas, operated at CDS, Strasbourg, France.

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
AUG 2011		

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Speckle Interfermometry At The U.S. Naval Observatory, XVII	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **U.S. Naval Observatory,3450 Massachusetts Avenue, NW,Washington,DC,20392**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited.

13. SUPPLEMENTARY NOTES
The original document contains color images.

14. ABSTRACT
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15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**		**5**	

Table 1
New WSI Pairs

Coordinates α, δ (2000)	Discoverer Designation	$Mag_{primary}$ (est.)	$Mag_{secondary}$ (est.)	Note
00 45 08.08 +64 23 31.1	WSI 42 AC	10.2	11.	1
03 57 12.93 +32 00 42.6	WSI 29 BC	11.1	13.0	2
07 10 23.30 −12 21 58.0	WSI 27	10.9	12.5	3
09 16 02.27 −14 01 50.5	WSI 28	10.6	10.7	4
17 01 01.00 +68 05 06.9	WSI 35 AD	10.8	12.	5
19 39 20.56 +31 12 37.9	WSI 30	10.6	12.5	6
19 42 58.39 +38 32 10.1	WSI 46 AC	11.0	13.6	7
20 51 53.87 +33 27 09.3	WSI 47 AC	9.5	12.	8
23 24 15.83 +61 35 17.5	WSI 48 AE	8.4	12.3	9
23 39 44.25 +78 41 31.0	WSI 41	10.2	10.3	10

Notes. (1) New pair discovered in the same field of view as 00452+6424 STI 123. (2) B component of 03572+3201 SEI 33 discovered as closer pair. Measure of AC and BC given in Table 2. (3) Found while searching for 07103−1222 BRT2661. May be a common-proper-motion companion. (4) Found while searching for 09167−1407 BRT2716. May be a common-proper-motion companion. (5) New component of 17010+6807 MLR 199 discovered closer than known pair. Measure weak, but companion seen repeatedly. (6) New pair discovered in the same field of view as 13519+3359 ES 2145. (7) New component of 19429+3832 SEI 664 discovered closer than known pair. (8) New component of 20519+3327 GYL 26 discovered closer than known pair. (9) New component of 23243+6135 BLL 58 discovered closer than known pair. (10) New pair discovered in the same field of view as 23402+7843 WFC 243. May be a common-proper-motion companion.

dynamical or kinematic analysis all measures of a given pair should be precessed to a common epoch. Objects whose measures are of lower quality are indicated by colons following the position angle and separation. These lower-quality observations may be due to one or more of the following factors: close separation, large magnitude difference between components (Δm), one or both components very faint, a large zenith distance, and poor seeing or transparency. They are included primarily due to either the confirming nature of the observation or the number of years since the last measured position. The sixth column indicates the number of independent measurements (i.e., observations obtained on different nights) contained in the mean, and the seventh flags any notes. The 1588 mean positions in Table 2 have a median separation of 9.″51 and a mean separation of 13.″73.

The most common note indicators are either "C," indicating a confirming observation, or a number (N) indicating the number of years since the system was last measured. This is only given for systems with $N \geqslant 50$ yr. Forty-five systems are confirmed here. Since priority is given to both unconfirmed systems and to systems not observed recently, the time since last observation can be surprisingly large; for the systems in Table 2 the average time since the last observation is 14 years (47 years for those measures of reduced accuracy). Twenty-nine systems had not been observed in 50 years or more and 17 had not been observed for at least a century. The maximum such time span was 117 years for HJ 68 (last observed by Gauchet (1926) in 1893). The long delay in confirming these historic pairs was simply due to poor coordinates—most had only arcminute-precise published coordinates, precessed without proper-motion correction from the original coarse epoch-1820 α and δ. Also included in Table 2 are seven measures from 2007. Measures for these pairs, originally slated for Mason et al. (2008), were very different from historical values, so were withheld until those large differences could be confirmed.

Table 2
ICCD Measurements of Double Stars

WDS Desig. α, δ (2000)	Discoverer Designation	Epoch 2000.	θ (°)	ρ (″)	n	Note
00005+6713	HJ 1924	10.884	225.1	8.20	2	
00026+6606	STF 3053 AB	10.884	70.7	15.13	2	
00028+8017	STF 3051	10.884	23.6	16.69	2	
00029+7122	STF 3052	10.884	8.7	34.72	1	
00030+0723	HJ 3233	10.783	236.5	19.82	2	
00035+6041	STI 1261	10.886	165.8	10.90	2	
00042+2701	SMA 1	10.605	161.3	13.12	2	
00052+3020	STF 3058	10.957	51.3	12.54	1	
00066+2901	BU 1338 CD	10.957	209.9	3.02	1	
00076+0421	GRV 7	10.783	230.5	37.38	1	

Notes. C: confirming observation. F: first resolution of a new pair. See Table 1. O: based on proper motion of the primary and the time since the last observation, this pair appears to be optical. P: based on proper motion of the primary and the time since the last observation, this pair appears to be physical. N = 57–120: number of years since last measure.

(This table is available in its entirety in machine-readable and Virtual Observatory (VO) forms in the online journal. A portion is shown here for guidance regarding its form and content.)

2.3. Physical or Optical?

For those long-neglected wide doubles whose primaries have a large proper motion, a single new observation can occasionally allow us to determine whether the components share a common proper motion (cpm). Based on measures in Table 2, five of the pairs are characterized as optical and one as physical. These are flagged in Table 2 with notes.

2.4. Orbit and Linear Calculations

Table 3 presents the mean relative positions for 375 systems with published orbital determinations or linear solutions. The first six columns are identical to the corresponding columns of Table 2. Columns 7 and 8 give $O-C$ residuals (in θ and ρ) to the determination referenced in Column 9. The reference is either to a published orbit or to a determination in the "Catalog of Rectilinear Elements" (Hartkopf et al. 2006), indicated by the letter L. As may be expected, the objects in Table 3 tend to be more frequently observed than those in Table 2. The linear systems (N = 305) have a mean separation of 22.″45, and a mean time interval since last observation of only 2.9 yr. The orbit systems (N = 66) have a mean separation of 5.″79, and a mean time interval since last observation of only 0.6 yr. Four systems have both orbit and linear solutions, as coverage is as yet insufficient to differentiate between a straight line and a very gradual orbital arc. In nine cases, it is not yet possible to ascertain which of multiple published orbital determinations is to be preferred, so additional residual lines are provided.

2.5. Double Stars Not Found

Table 4 presents 14 systems which were observed but for which no secondary was detected. Possible reasons for nondetection include orbital or differential proper motion making the binary too close or too wide to resolve at the epoch of observation, a larger than expected Δm, incorrect pointing, and misprints and/or errors in the original reporting paper. It is hoped that reporting these will encourage other double star astronomers to either provide corrections to the USNO observations or to verify the lack of detection. Notes to some of these pairs highlighting possible reasons for nondetection are appended to the table.

Table 3
Measurements of Systems with Orbits or Rectilinear Solutions

WDS Desig. α, δ (2000)	Discoverer Designation	Epoch 2000.+	θ (°)	ρ (″)	n	$O-C$ (°)	$O-C$ (″)	Reference
00033+6053	HJ 1928 AB	10.886	183.6	15.34	1	0.0	−0.14	L
00047+3416	STF 3056 AB-C	10.605	2.9	25.96	2	0.2	0.02	L
00169+4427	ES 1481	10.957	58.9	6.98	2	0.1	−0.14	L
00175+0019	STF 23 AB	10.783	217.7	9.66	1	−0.1	−0.01	L
00187+2545	HJ 1015 AB	10.605	289.9	5.31	2	1.1	0.22	L
00272+4959	STF 30 AB	10.938	314.3	13.44	1	0.4	−0.11	L
00277−1625	HJ 1968 AB	10.799	234.1	35.24	2	0.3	−0.17	L
00305+2208	HJ 1027	10.796	217.0	18.21	1	−0.5	−0.71	L
00360+2959	STF 42 AB	10.796	21.1	6.01	1	0.3	−0.28	Kisselev et al. (2009)
00378+2443	J 923	10.796	265.3	21.99	1	0.1	0.03	L

(This table is available in its entirety in machine-readable and Virtual Observatory (VO) forms in the online journal. A portion is shown here for guidance regarding its form and content.)

Table 4
Double Stars Not Found

WDS Desig. α, δ (2000)	Discoverer Designation	Most Recent Published Observation			Published Magnitude		Notes
		Date	Position Angle (θ)	Separation (ρ)	Primary	Secondary	
00382+0305	HDO 32 AB	1868	45	4.0	10.4	11.	
00484+0517	HEI 202 AB	1978	353	2.7	5.8	?	1,2
03109−0104	CHE 75	1910	221	14.3	?	?	1
04123−1820	RSS 71	1976	175	10.6	9.1	?	1
16243−1338	SIN 91 AC	1987	172	6.4	8.5	?	1
16243−1338	SIN 91 AD	1987	14	9.7	8.5	?	1
17184+0445	SLE 18	1982	333	17.7	11.0	11.5	
19000−0233	BRT 487	1897	58	4.2	11.0	11.3	
19359+0116	BAL 1523	1901	220	4.1	11.0	11.3	
20051−1136	H 4 3	1780	10	25.0	6.3	?	1
20134−1126	J 2304	1942	115	4.0	9.5	10.0	
20231+5504	OL 226	1916	41	3.8	11.	11.2	3
21106−0837	HJ 930	1922	115	10.2	10.1	10.4	4
22113+0317	HJ 957	1916	296	4.0	10.5	10.5	5

Notes. (1) No estimate of magnitude, so it may beyond the camera capability. (2) The AB pair was seen on two photographic plates by Heintz & Borgman (1984), but the companion was not visible on 164 other plates, nor was it seen on repeated checks with a micrometer. The parallax plates also yield large residuals, leading Heintz & Borgman to suspect variability. (3) Although listed as a measure of 00035+3434 OL 77 by Olivier (1920), neither the coordinates nor the measure agreed with that pair, so it was been assigned a new designation. This measure (40.°7, 3.″79) could conceivably be a measure of 18547−1946 OL 80 with a 100.°0 error; however, the near-zero Δm does not agree with the ∼2 mag Δm expected for OL 80. (4) Measured twice by Herschel (1829) and Gauchet (1925), the most recent measure is quoted above. No companion seen near either position. Herschel's measure would imply a separation of ∼17″ at approximately the same position angle if both measures are accurate. No companion was seen. (5) This pair has been measured four times (Herschel 1829; Burnham 1903; Jonckheere 1910; Doolittle 1923) by reliable observers. It is no doubt real but "lost."

Thanks to the instrument shop for telescope maintenance and for minimizing the amount of time we were down when the dome rotation cable was replaced.

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